

CLAIMS:

1 1. A three-dimensional (3-D) integrated chip system, comprising:
2 a first wafer including one or more integrated circuit (IC) devices;
3 a second wafer including one or more integrated circuit (IC) devices; and
4 a metal bonding layer deposited on opposing surfaces of the first and second wafers at
5 designated locations to establish electrical connections between active IC devices on the first and
6 second wafers and to provide metal bonding between the adjacent first and second wafers, when
7 the first wafer is pressed against the second wafer using a flexible bladder press to account for
8 height differences of the metal bonding layer across the opposing surfaces of the first and second
9 wafers.

1 2. The three-dimensional (3-D) integrated chip system as claimed in claim 1,
2 wherein the metal bonding layer includes a plurality of Copper (Cu) lines on opposing surface of
3 the first and second wafers to serve as electrical contacts between active IC devices on both the
4 first and second wafers.

1 3. The three-dimensional (3-D) integrated chip system as claimed in claim 1,
2 wherein the flexible bladder press is a hollow steel container including an input valve arranged
3 to input air pressure, and a bottom membrane positioned over the surface of the first wafer to

1 apply the pressure differently at different points on the first wafer as the first wafer is pressed
2 against the second wafer to account for the height differences of the metal bonding layer across
3 the opposing surfaces of the first and second wafers.

1 4. The three-dimensional (3-D) integrated chip system as claimed in claim 1,
2 wherein the pressure required to account for the height differences of the metal bonding layer
3 across the opposing surfaces of the first and second wafers is determined based on the following
4 equations:

$$\delta = \frac{qL^4}{8EI}, \text{ and } I = \frac{bh^3}{3}$$

6 where " δ " indicates the total deflection on the first wafer; "L" indicates the length of the
7 first wafer; "q" indicates the load intensity; "E" is the Young modulus of elasticity of the first
8 wafer; and "I" indicates the moment of inertia of the rectangular cross-section; and
9 where "h" indicates the thickness of the first wafer, and "b" indicates the cross-section
10 dimension of the first wafer.

1 5. The three-dimensional (3-D) integrated chip system as claimed in claim 1,
2 wherein the first wafer is thinner than the second wafer to conform to the height differences of
3 the metal bonding layer across the opposing surfaces of the first and second wafers.

1 6. The three-dimensional (3-D) integrated chip system as claimed in claim 1,
2 wherein the flexible bladder press is an autoclave including an input valve arranged to input
3 high-pressure gas into a chamber; a heater arranged to heat the gas at a predetermined
4 temperature; and at least one vacuum bag arranged to contain the first and second wafers in
5 position for metal bonding.

1 7. The three-dimensional (3-D) integrated chip system as claimed in claim 6,
2 wherein the vacuum bag is a flexible bag that is evacuated and then sealed to ensure that the first
3 and second wafers are bonded, via the metal bonding layer.

1 8. A wafer bonding method, comprising:
2 selectively forming metallic bumps on opposing surfaces of adjacent wafers each
3 including one or more integrated circuit (IC) devices;
4 selectively aligning the adjacent wafers to form a stack; and
5 bonding the metallic bumps on the surface of one wafer with the metallic bumps on the
6 surface of the other wafer to establish electrical connections between active IC devices on the
7 adjacent wafers using a flexible bladder press to account for height differences of the metallic
8 bumps across the opposing surfaces of the adjacent wafers.

1 9. The wafer bonding method as claimed in claim 8, wherein the metallic bumps are
2 Copper (Cu) bumps deposited on opposing surface of the first and second wafers to serve as

1 electrical contacts between active IC devices on both the first and second wafers.

1 10. The wafer bonding method as claimed in claim 8, wherein the flexible bladder
2 press is a hollow steel container including an input valve arranged to input air pressure, and a
3 bottom membrane positioned over the surface of the first wafer to apply the pressure differently
4 at different points on the first wafer as the first wafer is pressed against the second wafer to
5 account for the height differences of the metallic bumps across the opposing surfaces of the first
6 and second wafers.

1 11. The wafer bonding method as claimed in claim 8, wherein the pressure required
2 to account for the height differences of the metallic bumps across the opposing surfaces of the
3 first and second wafers is determined based on the following equations:

4
$$\delta = \frac{qL^4}{8EI}, \text{ and } I = \frac{bh^3}{3}$$

5 where " δ " indicates the total deflection on the first wafer; "L" indicates the length of the
6 first wafer; "q" indicates the load intensity; "E" is the Young modulus of elasticity of the first
7 wafer; and "I" indicates the moment of inertia of the rectangular cross-section; and

8 where "h" indicates the thickness of the first wafer, and "b" indicates the cross-section
9 dimension of the first wafer.

1 12. The wafer bonding method as claimed in claim 8, wherein the first wafer is
2 thinner than the second wafer to conform to the height differences of the metallic bumps across
3 the opposing surfaces of the first and second wafers.

1 13. The wafer bonding method as claimed in claim 8, wherein the flexible bladder
2 press is an autoclave including an input valve arranged to input high-pressure gas into a
3 chamber; a heater arranged to heat the gas at a predetermined temperature; and at least one
4 vacuum bag arranged to contain the first and second wafers in position for metal bonding.

1 14. The wafer bonding method as claimed in claim 13, wherein the vacuum bag is a
2 flexible bag that is evacuated and then sealed to ensure that the first and second wafers are
3 bonded, via the metallic bumps.

1 15. A three-dimensional (3-D) integrated chip system, comprising:
2 a first wafer including one or more integrated circuit (IC) devices, and metallic bumps
3 arranged to electrical interconnection;
4 a second wafer including one or more integrated circuit (IC) devices, and metallic bumps
5 arranged for electrical interconnection and with alignment with the first wafer to form a stack;
6 and
7 a flexible bladder press arranged to press the first wafer against the second wafer to bond
8 the metallic bumps on the surface of the first wafer with the metallic bumps on the surface of the

1 second wafer and establish electrical connections between active IC devices on the adjacent
2 wafers.

1 16. The three-dimensional (3-D) integrated chip system as claimed in claim 15,
2 wherein the flexible bladder press is arranged to press the first wafer against the second wafer to
3 account for height differences of the metallic bumps across the opposing surfaces of the first and
4 second wafers.

1 17. The three-dimensional (3-D) integrated chip system as claimed in claim 15,
2 wherein the flexible bladder press is a hollow steel container including an input valve arranged
3 to input air pressure, and a bottom membrane positioned over the surface of the first wafer to
4 apply the pressure differently at different points on the first wafer as the first wafer is pressed
5 against the second wafer to account for the height differences of the metallic bumps across the
6 opposing surfaces of the first and second wafers.

1 18. The three-dimensional (3-D) integrated chip system as claimed in claim 15,
2 wherein the pressure required to account for the height differences of the metallic bumps across
3 the opposing surfaces of the first and second wafers is determined based on the following
4 equations:

5
$$\delta = \frac{qL^4}{8EI}, \text{ and } I = \frac{bh^3}{3}$$

1 where " δ " indicates the total deflection on the first wafer; "L" indicates the length of the
2 first wafer; "q" indicates the load intensity; "E" is the Young modulus of elasticity of the first
3 wafer; and "I" indicates the moment of inertia of the rectangular cross-section; and

4 where "h" indicates the thickness of the first wafer, and "b" indicates the cross-section
5 dimension of the first wafer.

1 19. The three-dimensional (3-D) integrated chip system as claimed in claim 15,
2 wherein the first wafer is thinner than the second wafer to conform to the height differences of
3 the metallic bumps across the opposing surfaces of the first and second wafers.

1 20. The three-dimensional (3-D) integrated chip system as claimed in claim 15,
2 wherein the flexible bladder press is an autoclave including an input valve arranged to input
3 high-pressure gas into a chamber; a heater arranged to heat the gas at a predetermined
4 temperature; and at least one vacuum bag arranged to contain the first and second wafers in
5 position for metal bonding.